

REMARKS

Claims 1-3 are currently pending in the subject application. By the instant amendment, claim 1 is amended to more particularly describe the subject matter of the invention. The amendments made to claim 1 introduce no new matter as the subject matter thereof may be found in the specification as originally filed at paragraph [0030].

Applicants appreciate the Examiner's acknowledgement of applicants' claim for foreign priority and the receipt of a certified copy of the priority document.

In view of the foregoing amendments and following remarks, reconsideration and withdrawal of the rejections in this application are respectfully requested.

A. Introduction

In the outstanding Office Action mailed October 4, 2002, the Examiner objected to drawing FIGS. 1A and 1B for not being designated as Prior Art. The Examiner objected to the abstract for comparing the invention with the prior art. The Examiner rejected claims 1-3 under 35 U.S.C. § 103(a) as being unpatentable over United States Patent No. 6,376,355 to Yoon et al. ("the Yoon et al. reference") in view of United States Patent No. 6,143,645 to Hsu et al. ("the Hsu et al. reference").

B. Objection to the Figures

In the outstanding Office Action, the Examiner objected to Figures 1A and 1B for not including a legend such as "Prior Art."

Applicants submit herewith proposed drawing corrections to FIGS. 1A and 1B to include the legend "Prior Art." Upon receipt of the Examiner's approval of the proposed drawing corrections, applicants will submit formal drawings reflecting the proposed drawing corrections.

C. Objection to the Abstract

In the outstanding Office Action, the Examiner objected to the Abstract for comparing the invention to the prior art.

The Abstract has been amended to remove the comparison of the present invention with the Prior Art. Accordingly, withdrawal of the objection to the Abstract is respectfully request.

D. Asserted Obviousness Rejection of Claims 1-3 Under 35 U.S.C. § 103(a)

In the outstanding Office Action, the Examiner rejected claims 1-3 under 35 U.S.C. § 103(a) as being unpatentable over the Yoon et al. reference in view of the Hsu et al. reference.

In the outstanding Office Action at p. 3, the Examiner asserts that the Yoon et al. reference teaches:

selectively depositing an anti-nucleation layer on the barrier metal except in the recess region, and depositing a metal layer (tantalum or titanium) on the barrier metal except in the recess region (Fig. 2, 7-9, col. 1, lines 55-67, col. 2, lines 1-5, 12-15, 25-28, 60-63, col. 4, lines 60-65, col. 5, lines 17-23, 45-49, 63-64).

Office Action of October 4, 2002, at p. 3.

However, it is respectfully submitted that the metal layer referred to by the Examiner is the material layer 111, which is deposited to form the anti-nucleation layer 113, and hence, is deposited prior to formation of the anti-nucleation layer 113, and thus cannot be formed on the

anti-nucleation layer and the barrier metal except in the recess region, as claimed in claim 1 of the subject application.

The Examiner is respectfully redirected to the Yoon et al. reference at FIG. 2 and col. 5, line 43 - col. 7, line 4, in which formation of a copper layer 110, an anti-nucleation layer 113 and a metal liner 115 are described. In the section cited above, the Yoon et al. reference teaches a material layer 111 of aluminum, titanium or tantalum, is formed on a structure where a copper layer 110 is formed on an entire surface of an annealed barrier layer 109. It is the material layer 111 that is formed into the anti-nucleation layer 113. At col. 6, lines 35-50 and 63-67, the Yoon et al. reference teaches:

[A]t this stage, the material layer 111 is selectively formed only on the barrier metal layer 109 on the interdielectric layer pattern 105. The barrier metal layer 109 formed in the recessed region is exposed. Then, the resultant structure where the material layer 111 is formed is exposed to air or oxygen plasma, oxidizing the material layer 111, and thereby forming an anti-nucleation layer 113, i.e. an aluminum oxide (Al_2O_3) layer, a titanium oxide (TiO_2) layer or a tantalum oxide (Ta_2O_5) layer.

When the material is oxidized by exposure to air, as shown in FIG. 2, the material layer 111 may be partially changed to the anti-nucleation layer 113. Also, when the material layer 111 is formed of an aluminum layer, then the anti-nucleation layer 113 may be formed of an aluminum nitride layer (AlN).

The Yoon et al. reference at col. 6, lines 35-50, (emphasis added).

Meanwhile, the anti-nucleation layer 113, i.e., an aluminum oxide layer, an aluminum nitride layer, a titanium oxide layer or a tantalum oxide layer, may be formed through an O_2 reactive sputtering process or N_2 reactive sputtering process.

The Yoon et al. reference at col. 6, lines 63-67.

The Yoon et al. reference goes on to teach formation of a metal liner inside the recess, as illustrated in FIGS. 2-4 and taught at col. 7, lines 29-32:

[A]lso, a metal liner 115; i.e. a copper liner, is selectively formed only on a surface of the exposed copper layer 110 or the exposed barrier metal layer 109 to a thickness less than 10 Å.

The Yoon et al. reference at col. 7, lines 29-32.

Finally, the Yoon et al. reference teaches formation of the metal plug 117 and metal layer, or interconnect 119, as illustrated in FIGS. 3-5 and described at col. 7, line 45 – col. 9, line 6.

Specifically, at col. 7, lines 63-64, the Yoon et al. reference teaches:

the metal plug 117 is selectively formed only in the recessed region.

The Yoon et al. reference at col. 7, lines 63-64.

Therefore, as may be seen in the above passages, there is no metal or metal alloy formed to prevent aluminum migration on the anti-nucleation layer and the barrier metal except in the recess region in the Yoon et al. reference as claimed in amended claim 1 of the subject application. Rather, the Yoon et al. reference teaches selectively forming a metal liner 115 only on a surface of the exposed copper layer 110 or the exposed barrier metal layer 109. Then, the Yoon et al. reference teaches selectively forming metal plug 117 only in the recessed region 111, and forming an interconnection metal layer 119 on the entire surface, including anti-nucleation layer 113. The Yoon et al. reference does not teach or suggest forming a metal or a metal alloy for inhibiting aluminum growth on the anti-nucleation layer and the barrier metal except in the recess region, prior to forming the interconnection layer, as claimed in claim 1 of the subject application.

In the present invention as claimed, a metal or a metal alloy is deposited in-between the anti-nucleation layer and the interconnect metal layer of reflowed PVD-Al, to provide surroundings in which the PVD-Al is able to migrate on a metal or a metal alloy, rather than on the anti-nucleation layer during the reflow process. Preventing migration of the PVD-Al layer on the anti-nucleation layer inhibits grain growth, thereby preventing abnormal patterning or "ring defects" in a semiconductor device.

In the outstanding Office Action at p. 3, the Examiner asserts that the Yoon et al. reference recites the necessity to avoid aluminum diffusion at col. 1, lines 33-40. However, applicants respectfully submit that the aluminum diffusion problem addressed by the Yoon et al. reference at col. 1, lines 33-40, refers to a different aluminum diffusion problem which occurs when aluminum in the interconnect plug penetrates through shallow source/drain regions of a transistor, thereby causing junction spiking at the drain/substrate and source/substrate junctions. This problem, however, is totally unrelated to the problem of aluminum migration on an anti-nucleation layer addressed by the present invention as claimed in claim 1. Therefore, it is respectfully submitted that the reference in the Yoon et al. reference does not render the present invention as claimed obvious, as the aluminum diffusion problem addressed by the prior art is of a completely different nature than that of the present invention. Therefore, claim 1 of the present invention is believed to be patentably distinguished over the Yoon et al. reference.

Regarding the Hsu et al. reference, applicants respectfully submit that the Hsu et al. reference does not teach or suggest forming a metal or a metal alloy for inhibiting aluminum migration on the anti-nucleation layer and the barrier metal except in the recess region as claimed

in claim 1 of the subject application. Rather, the Hsu et al. reference teaches forming a diffusion barrier layer 510 of TiN or SiN on a wetting agent layer 500 formed of TiSi. However, the diffusion barrier layer 510 of the Hsu et al. reference is for preventing diffusion of the wetting agent 500 into a metal layer 520, except at a sidewall of the recess region. *See the Hsu et al. reference at col. 3, lines 18-44, col. 4, lines 44-45 and 52-54 and FIGS. 2C1 and 3.*

The Hsu et al. reference addresses forming a barrier layer to prevent diffusion of wetting agent constituents (Ti and Si) into an Al alloy metal layer, and does not address a problem that occurs when an aluminum layer migrates on an anti-nucleation layer, or prevention of such migration, as is addressed by claim 1 of the subject application. Furthermore, the aluminum on the wetting layer in the Hsu et al. reference is deposited by extrusion or sputtering, unlike in the present invention as claimed. Therefore, the diffusion barrier layer and process of the Hsu et al. reference are different from those of the present invention as claimed, and do not render the present invention as claimed in claim 1 obvious.

Because neither the Yoon et al. reference nor the Hsu et al. reference teach a metal or metal alloy for inhibiting aluminum migration on the anti-nucleation layer and the barrier metal except in the recess region, as claimed in claim 1, it is respectfully submitted that the combination of these two cited prior art reference does not anticipate or render obvious the present invention as claimed.

Accordingly, reconsideration and withdrawal of the rejection of claim 1 are respectfully requested.

Further, because claims 2 and 3 depend from claim 1, which is now believed to be in condition for allowance, claims 2 and 3 are believed to be similarly allowable as depending from an allowable base claim. Accordingly, reconsideration and withdrawal of the rejections of claims 2 and 3 are respectfully requested.

E. Conclusion

Since the cited prior art references, alone or combined, do not anticipate or render obvious claims 1-3 of the subject application, it is respectfully submitted that these claims are in condition for allowance, and a notice to such effect is respectfully requested.


Finally, if the Examiner believes that additional discussions or information might advance the prosecution of the instant application, the Examiner is invited to contact the undersigned at the telephone number listed below to expedite resolution of any outstanding issues.

In view of the foregoing amendments and remarks, reconsideration of this application is respectfully requested, and favorable action upon claims 1-3 is hereby requested.

Respectfully submitted,

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Date: January 6, 2003



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**PETITION and
DEPOSIT ACCOUNT CHARGE AUTHORIZATION**

This document and any concurrently filed papers are believed to be timely. Should any extension of the term be required, applicant hereby petitions the Director for such extension and requests that any applicable petition fee be charged to Deposit Account No. 50-1645.

If fee payment is enclosed, this amount is believed to be correct. However, the Director is hereby authorized to charge any deficiency or credit any overpayment to Deposit Account No. 50-1645.

Any additional fee(s) necessary to effect the proper and timely filing of the accompanying papers may also be charged to Deposit Account No. 50-1645.